Changes in the chemical composition of soils during the development of gas fields in the south-west of the Aral sea

Murat B. Jollibekov*, *Bibigul S.* Tleumuratova, and *Elzura P.* Urazymbetova

Karakalpak Scientific Research Institute of Natural Sciences of Academy of Science Republic of Uzbekistan, Karakalpak, Republic of Uzbekistan

Abstract. The article presents an assessment of technogenic impact on the development of gas fields in the south-west of the Aral Sea regions. As a result of monitoring activities and conducted scientific research (2011-2012), a significant amount of data on the state of the natural environment in this region has been accumulated and data on the chemical composition of soils are presented. However, the processing of the received information consists mainly in comparing data on pollutants with the maximum permissible concentration (MPC). In particular, the dynamics of long-term anthropogenic impact on soil quality is determined by the soil/rock formations processes. Examples of technogenic impact of the Ustyurt gas-chemical complex on the environment are given. The scientific novelty of the work lies in taking into account the spatial dynamics of soil pollution (analysis of the dynamics of the chemical composition of soils depending on the distance from the source of pollution), the proposed method of gradient indication of the degree of pollution, based on a quantitative assessment of the spatial dynamics of pollution, the assessment of the summation effect using a normative characteristic - total concentration homogeneous pollutants.

1 Introduction

Environmental pollution is a global problem of present time. In this regard, the development of methods for monitoring, quantitative assessment, and mitigation of anthropogenic stress in the natural environment occupy a significant place in environmental research. All over the world, the development of industry is accompanied by an examination for compliance with the requirements of technical regulations, dictated by the presumption of environmental danger of the planned economic and other activities [1].

With the discovery of the Western Aral natural gas fields with a preliminary estimate of reserves in the amount of 11 billion cubic meters and Surgil, whose reserves are about 120 billion cubic meters, man-made pollution is superimposed on the existing unfavorable ecological situation of the Aral Sea and the drained bottom.

* Corresponding author: beckuzb@gmail.com

As a result of monitoring activities at the above deposits by the State Committee for Ecology and Environmental Protection of the Republic of Karakalpakstan and conducted scientific research [2, 3, 4], a significant amount of data on the state of the natural environment in this region has been accumulated. However, the processing of the received information consists mainly in comparing data on pollutants (Pollutants) with the maximum permissible concentration (MPC). At the same time, the dynamism of long-term anthropogenic impact requires an in-depth study of pollution processes using quantitative methods to identify patterns and trends in the dynamics of the state of the environment [7, 8]. In particular, the dynamics of long-term anthropogenic impact on soil quality is due to the following factors:

1) accumulation of pollutants;

2) the destruction of complex organic substances and their transformation into simple inorganic compounds;

3) influence on soil microflora;

4) the influence of terrestrial biota through accumulation in plant and animal tissues;

5) diffuse, capillary-convective and infiltration processes in the soil;

6) the ability of the environment to self-purify;

7) wind erosion of surface contaminated soil layers.

In connection with this dynamism, studies of the technogenic impact of the Ustyurt gas-chemical complex (UGCC) on the environment should be carried out in stages.

The purpose of this work was a quantitative assessment of soil pollution based on the materials of field studies carried out at the first stage (2011-2012) of the activities of the company JV LLC "UzKorGasChemical", given in [2, 4].

The scientific novelty of the work is as follows:

1. A method of gradient indication of the degree of pollution based on the analysis of spatial dynamics is proposed [10, 11].

2. Many pollutants associated with the technologies of the gas industry have a summation effect. In this paper, for the first time, to assess the ecological state of soils in the southwest of the drained bottom of the Aral Sea, such a normative characteristic as the total concentration is used [5].

2 Research methods and conditions

The object of study is the soils of the south-west of the drained bottom of the Aral Sea (Fig. 1). Note that Figure 1 is not scaled for clarity. The studies were carried out on radial segments to the north, south, northeast, southwest at distances of 100m, 500m, 1000m from the UGCC. The choice of these directions is predetermined by the macro and micro relief of the area, as well as hydrogeological conditions, the mechanical composition of soils and the wind regime, which determines the aeolian transport of pollutants with a predominance of northern and northeastern directions [9].

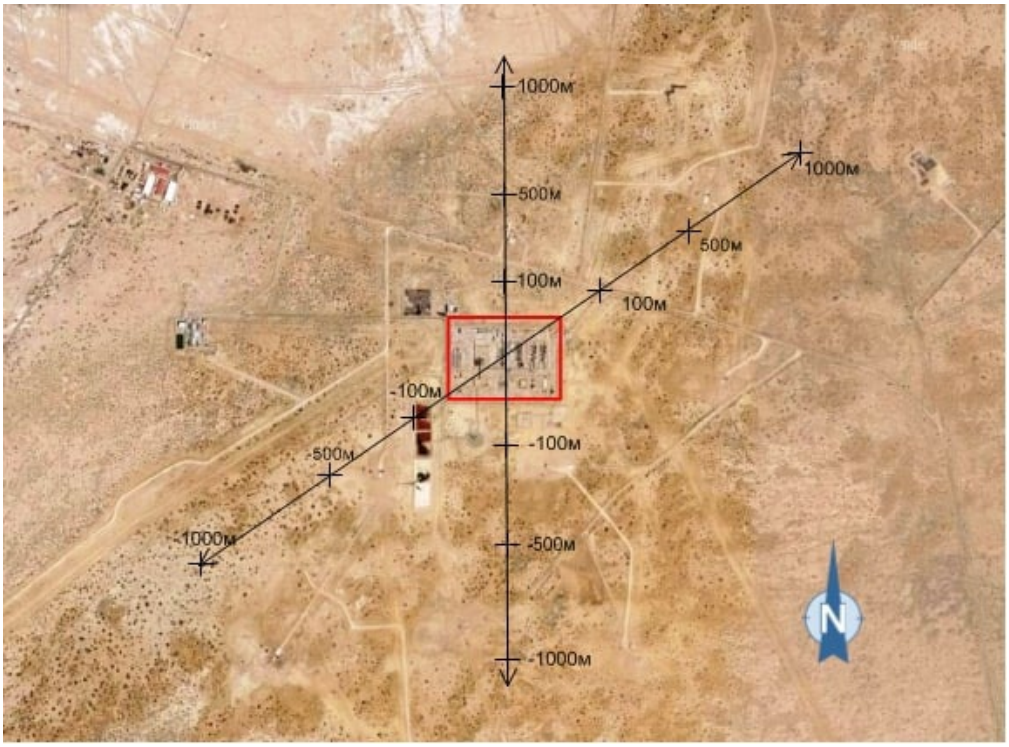

Fig. 1. Sampling points near the Surgil deposit.

The sources of pollution in the work are the UGCC plant, waste disposal sites, waste water storage tank. Soil pollution associated with the development of the Surgil deposit is expressed as follows:

1) Laying of roads;
2) Landfills of industrial and household waste;
3) Drilling wells for pumping groundwater;
4) Discharge of active waste drilling fluids.

Soil samples were taken at depths of 20 cm and 1 m. The studied ingredients are divided into 3 groups: heavy metals, pesticides and salts.

For each group, the dimensionless (relative) total concentration q was calculated:

$$q = \frac{C_1}{MPC_1} + \frac{C_2}{MPC_2} + \frac{C_3}{MPC_3} + \cdots + \frac{C_n}{MPC_n},$$

where C_i is the concentration of the *i*- substance of the group.

This value, according to Le Chatelier's law [5], should be less than or, in extreme cases, equal to 1, otherwise pollution by this group of substances is considered excessively strong.

The method of gradient indication of the degree of pollution by one or another ingredient, based on the analysis of spatial dynamics, consists in calculating the average concentration gradient G along the research route:

$$G_a = \frac{1}{n}\sum \frac{C_{i-1\ldots}C_i}{B}$$

where B is the background concentration of pollutants, C_i is the concentration at the *i* sampling point (Figure. 2).

The following interpretation of the G values based on the influence of an industrial facility (IF) is logical:

a) G=0 – IF does not affect the content of this ingredient in the soil;
b) 0<G<1 – insignificant reduction of the ingredient in the soil;
c) 1 <G - significant reduction of the ingredient in the soil;
d) -1 <G<0 – insignificant increase of the ingredient in the soil;
e) G<-1 – significant increase of this ingredient in the soil.

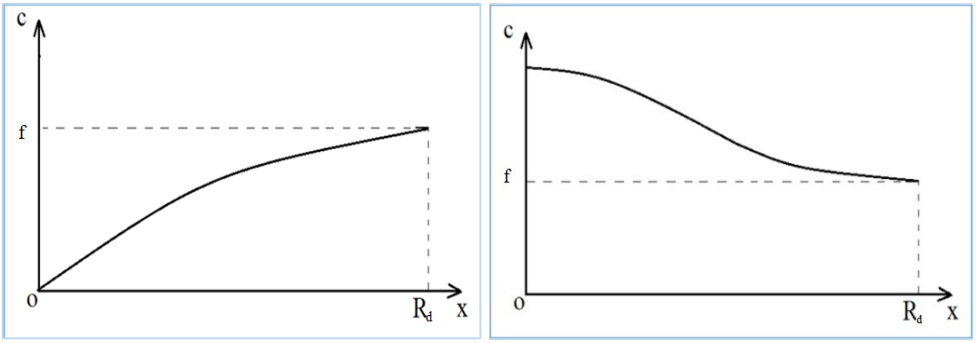

Fig. 2. Concentration profile of the *i* ingredient.

Figure 2 shows monotonous changes in the content of pollutants in the soil with asymptotic approximation to the background values. The point of equality of the background concentration is defined as the radius of action of the IF. Of course, other forms of the concentration curve with a change in the sign of the gradients (Fig. 3) are also possible, caused by the action of other factors, for example, interaction with other soil ingredients, the influence of terrestrial biota through accumulation in plant and animal tissues, etc. But the method is designed to quantify the direct impact of IF on changes in the content of a given ingredient in the soil.

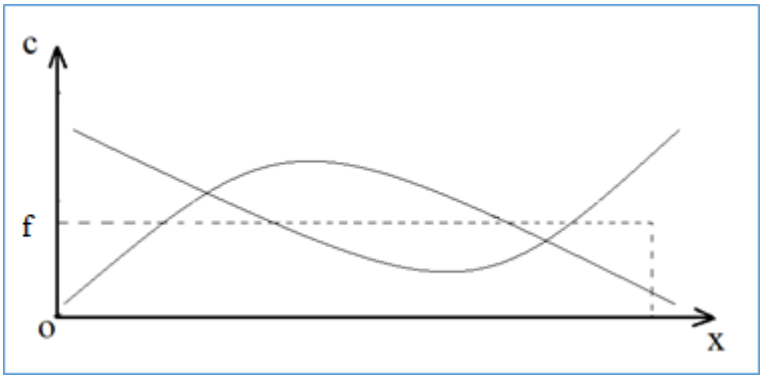

Fig. 3. The concentration of a substance with the action of other factors.

3 Results and discussion

Table 1 shows the results of the gradient indication of the degree of contamination with heavy metals. Soil samples were taken at a depth of 20 cm.

In general, calculations using the gradient indication method proposed by us showed an insignificant degree of influence on the content of heavy metals. The exception is Al, the

content of which, under the influence of the source of pollution, sharply decreases in the north direction, and increases towards the northeast [6].

The calculation of the total concentration at a distance of 100 meters from the pollution source showed that in the presence of the summation effect for these metals, soil pollution is significant, since it is more than 1 in all directions: N - 1.856, NE - 2.766, S - 1.598, SW - 1.594.

Table 1. G-values for Pb, Cd, Ni, Zn, Al, Fe, Cu

		North	North-east	South	South-west
Ingredients	Pb	-0.0029	-0.01375	0.00665	0.0069
	Cd	-0.00013	-0.0003	0.00018	0.00012
	Ni	-0.00095	-0.0006	-0.0014	0.0007
	Zn	-0.00285	0.00025	0.0145	0.02015
	Al	3.0835	-4.861	-0.0155	-0.0185
	Fe	-0.00175	-0.0045	0.0085	-0.00475
	Cu	-0.00035	-0.00075	0.0006	0.0005

4 Conclusion

Based on the study on the impact of the development of gas fields on the drained bottom of the Aral Sea on the content of heavy metals in soils, the following conclusions were drawn.

1. In the surveyed points, the content of heavy metals does not exceed the MPC. However, if there is a summation effect, the total concentration exceeds the allowable level. (100.0 mg/kg). The content of cadmium, nickel and zinc in the soils in the selected samples, the level of pollution is much lower than the background value.

2. The proposed method of gradient indication of the degree of pollution makes it possible to quantify the direction and degree of influence of industrial facilities on the state of the environment.

Authors' declaration

Conflicts of Interest: None. - Whereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.

Authors' contributions statement

All authors contributed to data analysis, drafting, or revising the manuscript.

Tables and figures in articles are clear and well configured within article content (are not just copied-pasted from Excel)

References

1. B.S. Tleumuratova, S.M. Mambetullaeva, *Environmental protection* (Tutorial, Tashkent: "Lesson press", 2022) 216.
2. M. Jollibekov, et al. *Information report on the selection and testing of soil and water samples at the project base of the UGCC of the Kungrad region and at the Surgil deposit of the Muynak region* (Nukus, 2011) 60.
3. M. Jollibekov, B. Jollibekov, A. Myrzambetov, V. Jollibekov, A. Orazymbetov, *Modern ecological state of groundwater in the drained bottom of the western part of the Aral Sea,* Agrotechnological issues of growing agricultural products. Thesis report of scientific practical conference (Nukus, 2011) 116-118.
4. K. Yoshiko, B. Jollibekov, M. Jollibekov, V. Jollibekov, *The content of toxic substances in soils on the territory of the Surgil deposit in the western part of the Aral Sea,* Challenges of the present, the main directions of development, Thesis All-Russian. scientific and practical. Conf. (Moscow, 2012) 587-590.
5. V.A. Vronsky, *Applied Ecology*, (Rostov on Don, Publishing house. "Phoenix", 1996) 327 – 329.
6. M.B. Jollibekov, B.S. Tleumuratova, E.P. Urazymbetova, *Technogenic soil pollution during the development of natural gas fields in the south-west of the drained bottom of the Aral Sea*, Collection of materials of the International Scientific and Practical Conference "Let's save the soil for our descendants", (Almaty, 2022) 52-56.
7. Y. Kawabata, et al., *Uranium Pollution of Grand Water in Karakalpakstan*, Uzbekistan, In: Merkel, B., Schipek, M. (eds) (The New Uranium Mining Boom, Springer Geology. Springer, Berlin, Heidelberg, 2011)
8. J.F. Cretaux, A. Kostianoy, M. Bergé-Nguyen, A. Kouraev, Present-Day Water Balance of the Aral Sea Seen from Satellite. In: Barale, V., Gade, M. (eds) (Remote Sensing of the Asian Seas, Springer, Cham, 2019)
9. M. Juliev, L. Gafurova, O. Ergasheva, M. Ashirov, K. Khoshjanova, M. Mirusmanov, *Land Degradation Issues in Uzbekistan,* In: Al-Quraishi, A.M.F., Mustafa, Y.T., Negm, A.M. (eds) Environmental Degradation in Asia (Earth and Environmental Sciences Library, Springer, 2022)
10. D. Malakhov, M. Batyrbayeva, I. Vitkovskaya, *A New Method for Land Degradation Assessment in the Arid Zone of Republic of Kazakhstan*, In: Al-Quraishi, A.M.F., Mustafa, Y.T., Negm, A.M. (eds) (Environmental Degradation in Asia, Earth and Environmental Sciences Library, Springer, Cham (2022)
11. R. Ghimire, V.R. Thapa, P. Acharya, J. Wang, U.M. Sainju, *Soil Indicators and Management Strategies for Environmental Sustainability*. In: Rakshit, A., Singh, S., Abhilash, P., Biswas, A. (eds) (Soil Science: Fundamentals to Recent Advances, Springer, Singapore, 2021)